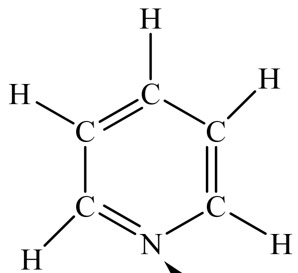
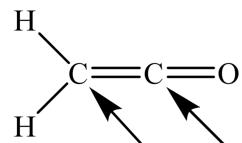
CHEM1611 Answers to Problem Sheet 4

1.



~120°: *sp*^{2} N making two C-N σ-bonds and one C-N π-bond and with weakly basic lone pair directed away but in the plane of the ring.



Three bonds around C: ~120°: *sp*^{2} C

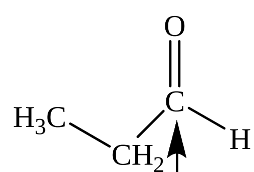
Two bonds around C: 180°: *sp* C

***sp*^{2} O with two lone pairs at ~120° from C=O**

Four bonds around C: ~109°: *sp*^{3} C

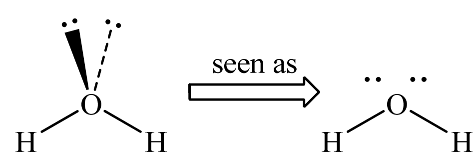
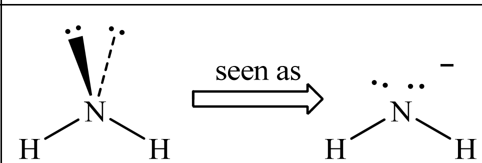
Two bonds around C: 180°: *sp* C

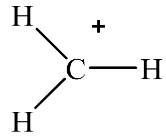
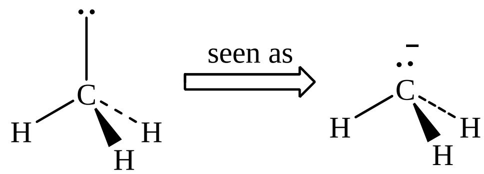
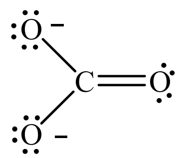
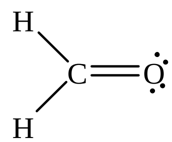
CH_3CH_2CHO =



three bonds around C: ~120° *sp*^{2} C

2.

Molecule/Ion	Shape		Hybridization
H_2O		**bent or angular**	***sp*^{3} O**
NH_2^-		**bent or angular**	***sp*^{3} N**

CH_3^+		**trigonal planar**	***sp*^{2} C**
CH_3^-	 	**trigonal pyramidal**	***sp*^{3} C**
CO_3^{2-}		**trigonal planar**	***sp*^{2} C**
H_2CO		**trigonal planar**	***sp*^{2} C**

3.

Species	Number of electron pairs around central atom	Number of bonding pairs around central atom	Number of non-bonding pairs around central atom	Geometry of molecule
NH_3	4	3	1	trigonal pyramidal
SF_6	**6**	**6**	**0**	**octahedral**
ClF_3	**5**	**3**	**2**	**'T'-shaped**
SF_4	**5**	**4**	**1**	**'see-saw'-shaped**

4. (a) **The molecules are all polar with δ+ C and H and δ- halogen. Dipole-dipole interactions are therefore possible alongside dispersion forces.**

(b) **Dipole-dipole forces would be expected to be largest in CH_2F_2 as fluorine is the most electronegative halogen. Dispersion forces would be expected to be largest in CH_2Br_2 as bromine is the largest halogen – its electron cloud is the most diffuse and easy to polarize. As the melting points increase as the halogen gets larger, it is probable the dispersion forces dominate.**

5. **A** **OH groups will probably H-bond to the receptor.**

B **The non-polar benzene ring with its easy to polarize π electrons will probably bind to the receptor via dispersion forces.**

C **OH group will probably H-bond to the receptor.**

D **The charged NH_2 group will be able to use ion/dipole-dipole and dipole-induced dipole interactions alongside H-bonding to attach to the receptor.**

6. (a) The number of moles (*n*) is related to the concentration (*c*) and the volume (*V*):

$$n = c \times V$$

As each mole of Na_3PO_4 contains one mole of PO_4^{3-}, 200 mL of a 0.090 M solution contains:

$$\text{number of moles of } PO_4^{3-} = (0.090 \text{ mol L}^{-1}) \times \frac{200}{1000} \text{ L} = 0.018 \text{ mol}$$

As each mole of $CaCl_2$ contains one mole of Ca^{2+}, 400 mL of a 0.10 M solution contains:

$$\text{number of moles of } Ca^{2+} = 0.10 \text{ mol L}^{-1} \times \frac{400}{1000} \text{ L} = 0.040 \text{ mol}$$

From the chemical equation, each mole of $Ca_5(PO_4)_3(OH)$ requires 3 moles of PO_4^{3-}(aq) and 5 moles of Ca^{2+}(aq).

To use all of the PO_4^{3-} present would require $\frac{5}{3} \times 0.018$ mol = 0.030 mol of Ca^{2+}. There is more than enough Ca^{2+} present to do this.

To use all of the Ca^{2+-} present would require $\frac{3}{5} \times 0.040$ mol = 0.024 mol of PO_4^{3-}. There is not enough PO_4^{3--} present to do this and so the amount of PO_4^{3-} determines the possible yield. Unreacted Ca^{2+}(aq) will be left.

From the chemical equation, one mole of hydroxyapatite is made from every three moles of PO_4^{3-}. As 0.018 mol is available:

$$\text{maximum possible yield of hydroxyapatite} = \frac{1}{3} \times 0.018 \text{ mol} = 0.0060 \text{ mol}$$

(b) **As the chloride ions do not take part in the reaction, the number of moles of Cl^-(aq) remaining in solution is equal to the number of moles present in 400 mL of a 0.10 M solution of calcium chloride. As each mole of $CaCl_2$ yields two moles of Cl^- ions,**

$$\text{number of moles of } Cl^- = 2 \times c \times V$$

$$= 2 \times (0.10 \text{ mol L}^{-1}) \times \frac{400}{1000} \text{ L} = 0.080 \text{ mol}$$

After the two solutions are mixed, the total volume is (200 + 400) mL = 600 mL. The concentration is thus:

$$\text{concentration of } Cl^- = \frac{n}{V} = \frac{0.080 \text{ mol}}{(600/1000 \text{ L})} = 0.13 \text{ mol L}^{-1} = 0.13 \text{ M}$$